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ANNUAL SUMMARY
OF
MOLECULAR BEAM STUDIES OF LOW ENERGY REACTIONS

ONR CONTRACT NO. N00014-80-C-0149

PRINCIPAL INVESTIGATOR: R. H. NEYNABER

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
	AD-A091	6-1119
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED
ANNUAL SUMMARY OF MOLECULAR BEAM STUDIES OF LOW ENERGY REACTIONS		Annual summary rept.
6. AUTHOR(s)		7. PERFORMING ORG. REPORT NUMBER
R. H. Neynaber		IRT-8199-001
		8. CONTRACT OR GRANT NUMBER(s)
		N00014-80-C-0149
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
IRT Corporation P.O. Box 80817 San Diego, CA 92138		NR 393-004
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE
ONR 800 N. Quincy St. Arlington, VA 22217		31 Oct 80
13. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		14. NUMBER OF PAGES
(29)		7
		15. SECURITY CLASS. (of this report)
		Unclassified
		16. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of this Report)		
Approved for public release; distribution unlimited.		
18. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
19. SUPPLEMENTARY NOTES		
20. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
Chemi-ionization Ion-molecule reactions Cross sections Molecular beams Reaction rates		
21. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
The annual summary of the research performed under ONR Contract No. N00014-80-C-0149 is given. The report describes merging-beams studies of chemi-ionization and ion-molecule reactions. Included are investigations of the Ne ⁺ -Ar ⁺ , He ⁺ -Ne ⁺ , and HCl ⁺ -Xe systems. A description is also given of how this research helps resolve unknown aspects of the areas investigated.		

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1. Contract Description

2. Scientific Problem

The composition of keV neutral rare gas beams formed by charge transfer of the rare gas parent ion beam in alkalis is unknown. The beams consist of rare gas metastables (generally in two states) and ground-state atoms. The technique for generating such beams is common, and information on the composition is needed in analyzing data obtained through their use. We have developed a method for obtaining the fraction of ground-state atoms in such beams by studying appropriate ion-molecule reactions. We will apply this method to determine unknown compositions.

[illegible]

No experimental information exists on low-energy resonant or near-resonant charge-transfer reactions between rare gas ions and metastables. Our experiments will supply such information. The data can be used to see if existing theories for charge transfer between ions and ground-state atoms can be extended to this case. We also will investigate energy distributions of product ions from which information on the reaction kinetics can be obtained.

3. Scientific and Technical Approach

Merging-beams techniques will be used for the studies. The two reactants of the process under investigation will be merged. Their velocities will be adjusted with respect to each other so that the desired relative energy in the center-of-mass system will be obtained. Product ions resulting from the reaction will be collected to give relative and absolute cross sections, and branching ratios will be obtained when appropriate.

4. Progress

We have made the following progress during the past contract period.

- a) Our results for chemi-ionization in the $\text{Ne}^+ - \text{Ar}^+$ system have been published. A paper on the subject was presented at the 11th Annual Meeting of the American Physical Society, Division of Electron and Atomic Physics, 10-12 December 1979, Rice University.
- b) A study was made of the Penning ionization of He^+ by Ne^+ over a range of relative kinetic energy of the reactants from 0.01 to 10 eV. Both absolute and relative cross sections were obtained and the results compared with our previous results of Penning ionization of Ne^+ by He^+ and associative ionization of He^+ and Ne^+ as well as with chemi-ionization in other systems of two colliding metastables.
- c) A review of some merging-beams studies at IRT Corporation was presented at the XIth International Conference on the Physics of Electronic and Atomic Collisions in Kyoto, Japan, 29 August-4 September 1979. The subject was associative and Penning ionization involving a metastable rare gas atom and a ground-state atom or two metastable rare gas atoms. The review was also published (see Section 5).

- d) Absolute and relative cross sections were obtained for the charge transfer reaction $\text{HCl}^+ + \text{Xe} \rightarrow \text{HCl} + \text{Xe}^+$. The reaction appears to be exothermic but, in fact, proved to be near-resonant. The near resonance is apparently fostered by the matching of electronic-vibrational-rotational energy levels of the entrance and exit channels. This results in the conversion of internal energy of HCl^+ into internal energy of HCl .

5. Publications

- a) R. H. Neynaber and S. Y. Tang, "Chemi-ionization in the Metastable Neon-Metastable Argon System," J. Chem. Phys. 72, 6176 (1980).
- b) R. H. Neynaber and S. Y. Tang, "Penning Ionization of Metastable Helium in the Metastable Helium-Metastable Neon System," J. Chem. Phys. 72, 5783 (1980).
- c) R. H. Neynaber, "Merging-Beams Experiments with Excited Atoms," Electronic and Atomic Collisions, North-Holland Publishing Company, Amsterdam, pp. 287-300 (1980).

6. Extenuating Circumstances

None.

7. We do not expect any unspent funds remaining at the end of the current contract period.

8-9. No graduate students or postdoctoral personnel have been associated with the contract.

10. R. H. Neynaber has received partial support from the Air Force Office of Scientific Research, Grant No. AFOSR-80-0244, but this support terminated 30 September 1980.

June 1978

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